Columbia University
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LAMONT GEOLOGICAL OBSERVATORY
PALISADES, NEW YORK

Technical Report on Meteorology No. 2

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Atmospheric Oscillations at Oklahoma City During the 1953 Tornado Season

by

William L. Donn, Richard Rommer and Frank Press

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ABSTRACT

Microbarovariograph records from an instrument installed in the U. S. Weather Bureau building in Oklahoma City sometimes show the passage of pressure jumps which were not recorded by conventional instruments, or they may show these effects in advance of those that are detected. Although tornadoes were frequent in connection with lines of pressure disturbance, none were close enough to determine with any certainty the warning value of a single instrument. A network of such instruments would be necessary to determine the continuity of events noted locally and indicate their use in the tornado problem. Pressure variations resulting from a thunderstorm passage indicate the latter to consist of a double convection cell. .

INTRODUCTION

In the spring of 1953 a sensitive microbarovariograph was installed by the Lamont Geological Observatory in the basement of the U.S. Weather Bureau building in Oklahoma City. The instrument is similar to that described by Ewing and Press (1) and Donn *et al.* (2). The purpose of the study was to detect, if possible, either micro-oscillation effects that might indicate approaching tornadoes or effects that might be sufficiently unique to tornado occurrence to be of value. Oklahoma City was selected owing to the high tornado frequency in that vicinity.

No tornadoes approached close to the instrument location during its operation but there were many within a radius of 100 miles of the station. The experiment has succeeded in indicating some significant oscillation effects which, if recorded by a network of similar instruments might prove of value in understanding the mechanism, and possibly giving warning of, tornado formation or approach.

Certain interesting pressure oscillations are also described which were noted in connection with thunderstorm passage, and which may shed further light on thunderstorm circulation.

EXPERIMENTAL RESULTS

June 4-6, 1953

According to the synoptic map for 0630, June 4 (all times used are GMT) in Fig. 1, a stationary front extends across the western tip of the Oklahoma panhandle. An elongated zone of precipitation lies to the east of and parallel to the front. Generally squally conditions extend northeastward from, and in line with the precipitation area for a considerable distance. The Oklahoma City microbarovariogram shows oscillations[1] (Fig. 2) beginning at 0830, which although of low amplitude are characteristic of pressure-jumps (2). A similar effect occurs again at 1004. From the surface observations in Table I and subsequent maps, it is apparent that no synoptic evidence of squall-line passage exists. Also, no pressure jumps were reported in the area at these times.

Two interpretations appear possible. The short series of oscillations beginning at 0830 may be the pressure jump genetically related to the squall zone suggested by and conforming to the shower band in Fig. 1. The pressure-drop at 1004 followed by a short series of oscillations an hour later might then indicate the passage of this incipient squall. According to this explanation, the pressure-jump would have outrun the squall zone generated by its passage through a region of latent or convective

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1. For oscillations having the periods considered here, the deflection of the trace is proportional to the rate of change of pressure rather than the actual pressure. An up-deflection means a pressure increase and down deflection a pressure decrease.

instability. Similar effects have been noted in a previous investigation (2). A second possibility is that the two pressure events represent the passage of independent successive pressure jumps, which according to current theory (3) have been generated by the fluctuation of the quasi-stationary front.

It is suggested again that the pressure-jumps trigger the squall-lines by releasing the instability through forced convection. In these cases, either there was not adequate instability, or the pressure-jumps were not strong enough. An array of these microbarovariographs in the area could have indicated whether evidence existed for these pressure phenomena necessary to support or reject these explanations.

Fig. 3 shows a small distinct oscillation at 0630, June 5, with a second set of oscillations beginning 0730. This conforms to a reported pressure-jump at 0655 (Table II). According to Fig. 4 a squall line identified at 0630 was just northwest of Oklahoma City. Fig. 5 shows it to have passed sometime during the following six hours. Thus the pressure oscillations beginning at 0745 probably mark the passage of this squall line. The surface observations at Oklahoma City in Table II confirm this. It seems noteworthy that the movement of the squall line occurred with and was probably initiated by, the fairly abrupt movement of the previously quasi-stationary front, as shown by a comparison of successive maps.

Since there is a high frequency of tornadoes associated with squall lines in this region, it seems significant that the development and subsequent passage of a squall may have been indicated in advance by the sensitive pressure variation instrument at Oklahoma City, at a time when perfectly clear weather prevailed there. On the other hand the instruments may have detected premature squall line development. In view of the close association of tornadoes with squall lines, this early observation of the latter could be very significant.

The spectacular variogram for June 5-6 is reproduced in Fig. 6. The first important oscillation occurs about 2145, June 5 (3:45 P. M., Local Time) with the first major oscillation at 2320, which coincides with the time of a reported pressure-jump for Oklahoma City. Many subsequent pressure-jump oscillations occur with intervening smaller oscillations. This interval of pronounced pressure disturbance persisted for nearly 12 hours. Severe thunderstorm activity and winds reaching hurricane force in gusts were reported for the station for the night of June 5 and probably account for much of the disturbance.

The weather map in Fig. 7 shows a new squall at the station at 0030, June 6. The approach of this was preceded by the pressure oscillations commencing 2145. Five tornadoes were reported with no specified times during the night of June 5 along a NE-SW line about 80 to 90 miles northeast and north of the station and one tornado reported about 2300, 90 miles west-southwest of the station. The front shown in Fig. 7 never reached Oklahoma City, but retreated to its former position after 0030, June 7. Since the tornadoes are genetically related to the movement of the front and squall line, the pressure disturbances and squally conditions recorded in the late afternoon at Oklahoma City certainly warn of approaching tornado conditions, even though none arrived locally in this case.

July 8-9, 1953

The pressure record for this date (Fig. 8) shows characteristic pressure-jump oscillations beginning 0216, July 9, preceded by a definite change in pressure signature at 0145. A series of small irregular oscillations is evident beginning about 0730, July 9. According to the 0630 map (Fig. 9), a squall line has recently passed the station, and a cold front is approaching, apparently explaining the pressure events just noted. This is confirmed in Table III. Note that the strong pressure oscillation at 0216, July 9 precedes the passage of the rain squall by almost one-half hour. The irregularity of the trace after 0145 is coincident with the wind velocity increase to as much as 70 mph in gusts, and probably results from turbulence and gustiness accompanying these high winds. Although no pressure-jump was reported for Oklahoma City, the jump shown here lies along an extrapolated pressure-jump isochrone on U.S. Weather Bureau pressure-jump project maps. The passage of the front, which is shown by the wind shift between 0728 and 0800, July 9, in Table III, coincides with the pressure oscillations at this time.

May 11-12, 1953

The pressure record in Fig. 10 shows a series of oscillations for about an hour beginning about 1700 May 11, with a strong pulse just following this time. Local surface observations show thunderstorms during this interval. A tornado was reported at Wynnewood, Oklahoma, 65 miles south-southeast of the station shortly after this time and was apparently related to these phenomena. Another series of oscillations (Fig. 10) commences prior to 0100, May 12 and culminates with the strong pressure change at 0200. No pressure-jumps were reported for Oklahoma City during either of these intervals. Local showers were again observed. A tornado advisory was issued by the Oklahoma City Weather Bureau at 1740 for the period from 1800 May 11 to 0200 May 12 which coincides very well with the observations. An attempt is made to explain these events synoptically by means of the surface charts for 1230 and 1830 May 11, and 0030 May 12 (Fig. 11).

This sequence, together with the hourly observations available, shows that no front reached or crossed the station during the critical interval. A trough line on the 1830, May 11 chart developed showery conditions along it, and is a line of convergence between Gulf and Continental air. It appears to be in the vicinity of Oklahoma City during the critical times referred to above, although not specifically delineated on the charts. A suitable distribution of pressure instruments would have indicated its position at all times and would also have indicated the strength of any convective conditions which may have been associated.

June 7, 1953

The pressure record for June 7 at 0600 (Fig. 12) shows a strong double oscillation having symmetrical positive and negative pressure changes in each cycle. This is distinctly different from the pressure-jump signatures previously studied wherein one or more positive surges are recorded which have no negative counterpart, or the reverse.

The synoptic map for June 7 at 0630 (Fig. 13) shows that a thunderstorm occurred at the station during the past hour. The existence of the short squall line shown on the map was not confirmed by any of the data of the pressure-jump project of the Weather Bureau, nor by the synoptic data shown on this map. The striking pressure pattern beginning at 0600 appears to be the convection signature of a simple thunderstorm.

The character of the two-cycle oscillation is suggestive of the Bénard double convection cell described by Brunt (4) and referred to by Clark (5) for similar phenomena. Such a cell, consisting essentially of two vertical rings with a common central updraft has a horizontal diameter of three times the vertical extent. Using surface temperature at the time, and average lapse rate, the freezing level is estimated to lie between ten to eleven thousand feet, or about two miles. This height can be taken to represent the approximate upper level of convection, and according to theory allows for a diameter of six miles for the total convectional circulation.

Assuming a velocity of 20 mph for the cell, the period of the double oscillation would be 18 minutes, which is just about the value of the observed period of the double oscillation.

The theory can be checked more carefully when more accurate thunderstorm observations are available. This type of data seems of definite value in thunderstorm studies.

CONCLUSIONS

1. The Oklahoma City microbarovariograph has recorded pressure-jump phenomena which were too small in magnitude to be detected by local conventional instruments and were not noticed elsewhere in the area. The pressure disturbances appear to have been related to immature squall lines. A suitable array of these instruments would indicate whether true continuity in propagation exists for these disturbances, or whether they are relatively local events.

2. Other pressure-jumps were recorded which were not otherwise noted locally but which were consistent with extrapolated isochrones of pressure-jump lines on maps of the Pressure-jump Project.

3. One strong jump recorded by regular equipment was anticipated by one and one-half hours by the microbarovariograph. Several tornadoes were associated with this disturbance but none was close to the station. In other cases tornadoes were present along lines of disturbances detected nearly simultaneously by the regular and the special instruments. Only a

network of these instruments could indicate whether they have any value in warning of the approach of tornadoes or in indicating pressure events unique to the formation of tornadoes.

4. Pressure variations attending the passage of a local thunderstorm show a striking double oscillation, distinct in character from regular pressure-jump signatures, and indicate the storm circulation to consist of a double convection cell whose parameters are consistent with those of the theoretical Bénard cell.

ACKNOWLEDGMENTS

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The study was made possible by the excellent cooperation of the U. S. Weather Bureau, and in particular Mr. M. E. Maughan, in charge of the Oklahoma City station, and Dr. Morris Tepper, in charge of the Pressure-jump Project. Prof. Maurice Ewing aided in the planning of the project and gave helpful criticism in the preparation of the manuscript. J. Hirshman and H. Smith installed the equipment in Oklahoma City. Miss O. Haselau was responsible for the drafting involved in the report preparation.

REFERENCES

1. Ewing, M. and F. Press, "Further study of atmospheric pressure fluctuations recorded on seismographs", Trans. Amer. Geophys. Un. 34:1, 95-100, 1953

2. Donn, W., R. Rommer, F. Press and M. Ewing, "Atmospheric oscillations and related synoptic patterns", Lamont Geol. Obs. Tech. Rep. on Meteorol. No. 1, 1953

3. Tepper, M., "A proposed mechanism of squall lines: the pressure-jump line", J. Meteorol. 7:1, 21-29, 1950

4. Brunt, D., "Physical and Dynamical Meteorology", Cambridge Univ. Press, 219-221, 1939

5. Clark, R., "Atmospheric micro-oscillations", J. Meteorol. 7:1, 70-75, 1950

TIME (GMT)	CEILING (hundreds of feet)	SKY	VISIBILITY (miles)	WEATHER and OBSTRUCTIONS TO VISION	SEA LEVEL PRESS. (mbs.)	TEMP. (°F)	DEW PT. (°F)	WIND DIRECTION	SPEED (m.p.h)	REMARKS and SUPPLEMENTAL CODED DATA
TABLE I OKLAHOMA CITY JUNE 4, 1953										
0600		O	15					↑↖	10	
0628		O	15		075	76	66	↑↖	10	
0700		O	15					↑↖	10	
0728		O	15		075	75	66	↑↖	12	
0800		150 ⦶	15					↑↖	12	
0828		150 ⦶	15		068	75	65	↖	15	
0900	150 ⦶	300 ⦶	15					↖	14	
0928	150 ⦶	300 ⦶	15		064	74	65	↖	14	910 0766
1000	150 ⦶	300 ⦶	15					↖	15	
1028	150 ⦶	300 ⦶	15		064	73	64	↖	15	
1100	150 ⦶	300 ⦷	15					↖	21	
1128	150 ⦶	300 ⦷	15		064	73	65	↑↖	18	
1200	150 ⦶	300 ⦷	15					↑↖	14	
TABLE II OKLAHOMA CITY JUNE 5, 1953										
0600	70⦶ 120⦶ 250⦶		15					↑↖	18	
0628	70⦶ 120⦶ 250⦶		15		051	79	65	↑↖	18	OCNL LTGIC W-NW
0655	M 50⊕		15					→↗	7	PRJMP 2/35/39LTGCC W-NW
0728	M 38⊕		10		075	76	63	↘	12	WND SHFTD GRDLY LTGIC W to NE
0800	M 35⊕		10	RW--						(T thru N PRJMP 2/35/39)
0828	M 38⊕		10		071	73	61	↓↙	12	RWB47E10 LTGIC N to NE
0900	M 35⊕		15					↙	10	LTGIC NW to NE
0928	M 35⊕		15		071	72	61	↙	14	LTGIC NW to NE/020 5//5
1000	M 35⊕		15					↙	15	LTGIC N to NE
1028	M 40⦷ 250⊕		15		068	71	62	←↙	12	LTGIC NE
1100	40⦶ 250⦷		15					←	10	
1128		250⦷	15		064	70	62	←↖	11	ACC DSNT E
1200		E 250⦶	15					↖	16	
TABLE III OKLAHOMA CITY JULY 9, 1953										
0100		250⦶	15					↖	11	CBN THRU NE
0128		50⦶	15		139	90	71	↖	10	LINE CB NW THRU E
0200	50⦶	100⦶	15					←↖	8	LTGCG NW DARK N
0228	M 50⦷		15		152	87	72	↙22↑ 2024C		SQUALL APCHG from N
0245	30⦶M 50⊕		8	RW--				↓↙ 50 +	70	PRES RR
0300	30⦶M 50⊕		8	RW-				↓↙ 30 +	50	LTNG N-E
0328	M 45⊕		10	RW-	183	70	65	↓↙	20	451 9//8 RWB32 LTG N thru E
0400	50⦶M 100⊕		15	RW-				←	20	
0428	50⦶M100⊕		15		169	69	66	←	20	RADAT 04972/55 2112C RWE14
0500	50⦶M100⦷		15					←	12	
0528	50⦶M100⦷		15		169	71	68	←	12	LTGIC W
0601	50⦶M100⦶		15					↖	4	DSNT LTG S and W
0628	70⦶M100⊕		15		166	72	67	↖	6	DSNT LTG SE and W
0700	E100⦷		15					↑↗	3	
0728	100⦶		15		159	72	68	↓	5	
0800	M160⦷		15					↓↙	4	
0828	M160⦷		15		163	72	67	↓↙	17	
0900	M150⦷		15					↓	10	

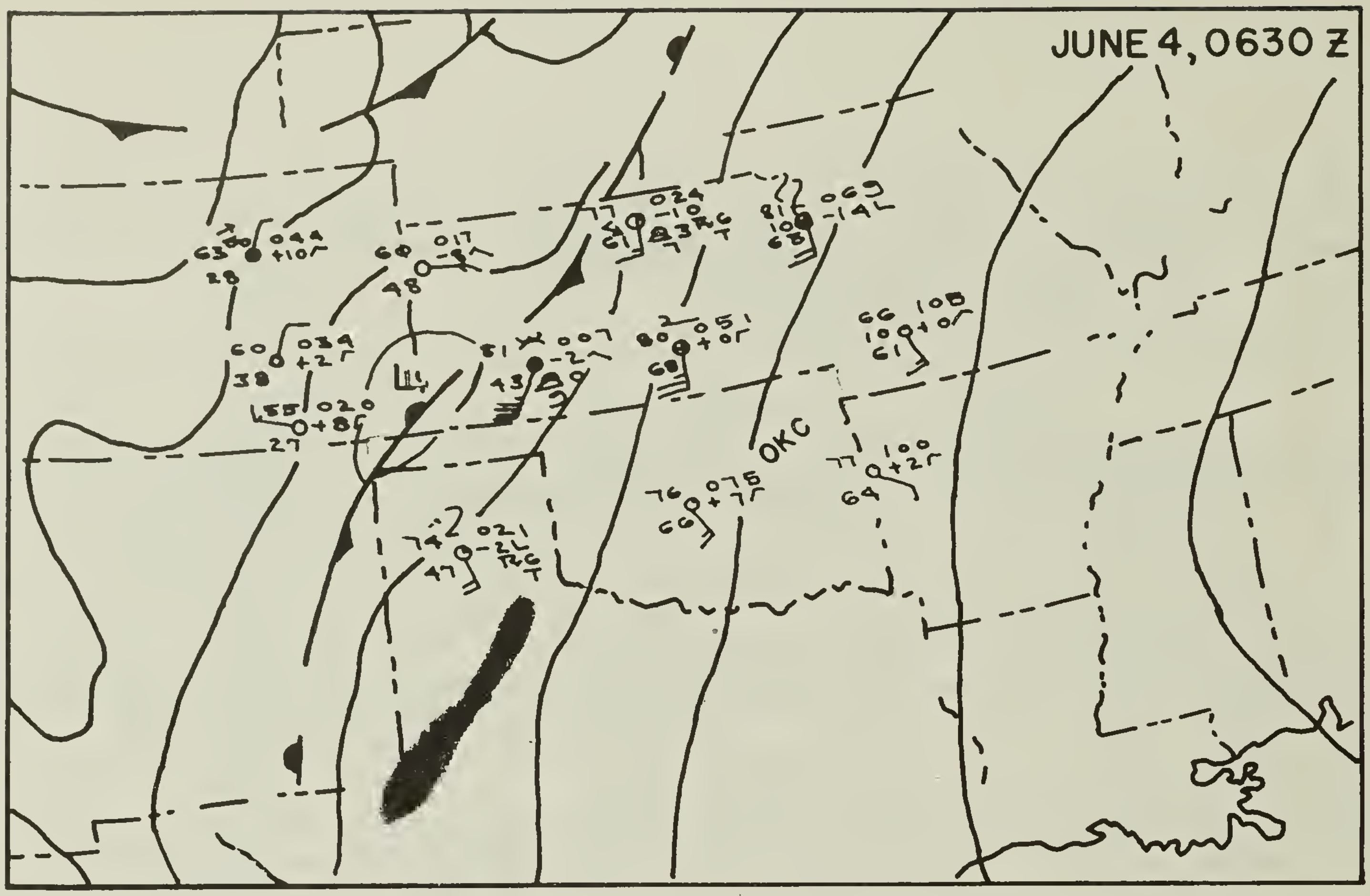

Figure 1. Surface weather map for area surrounding Oklahoma City (OKC) for June 4, 1953 at 0630 GMT

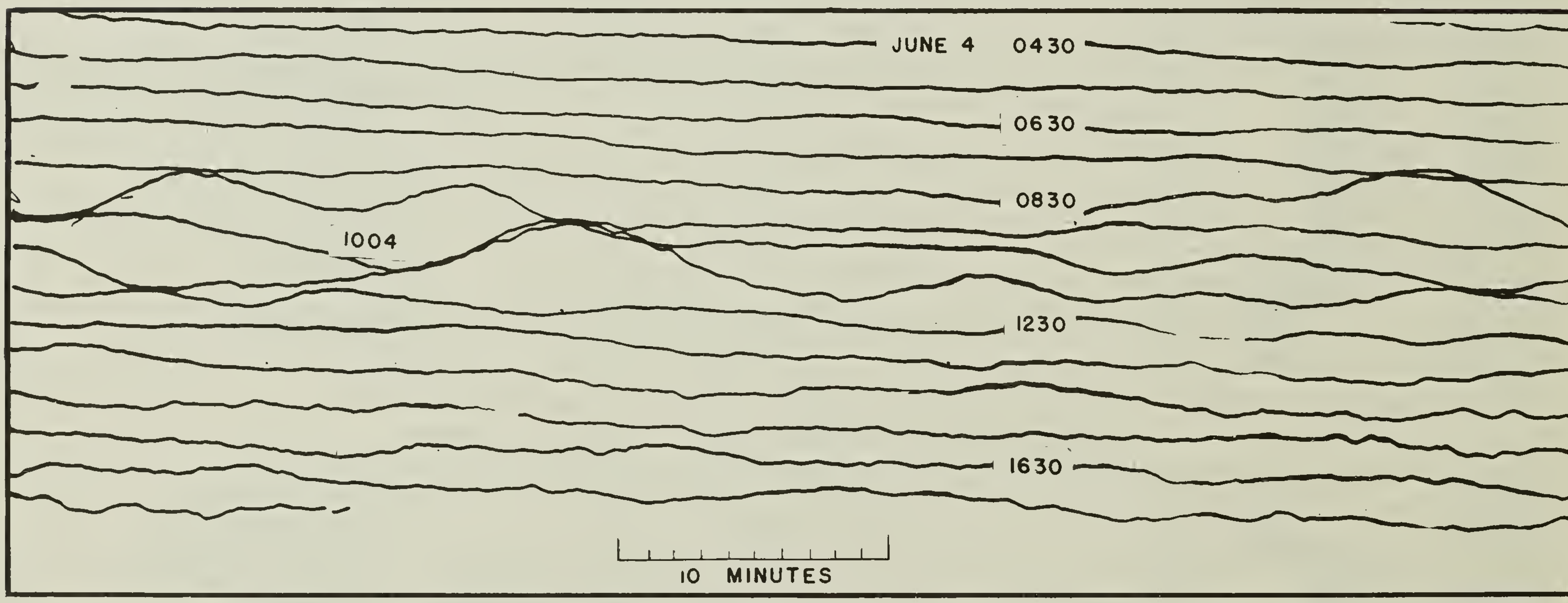

Figure 2. Portion of Oklahoma City microbarovariogram for June 4, 1953. (Times are GMT.)

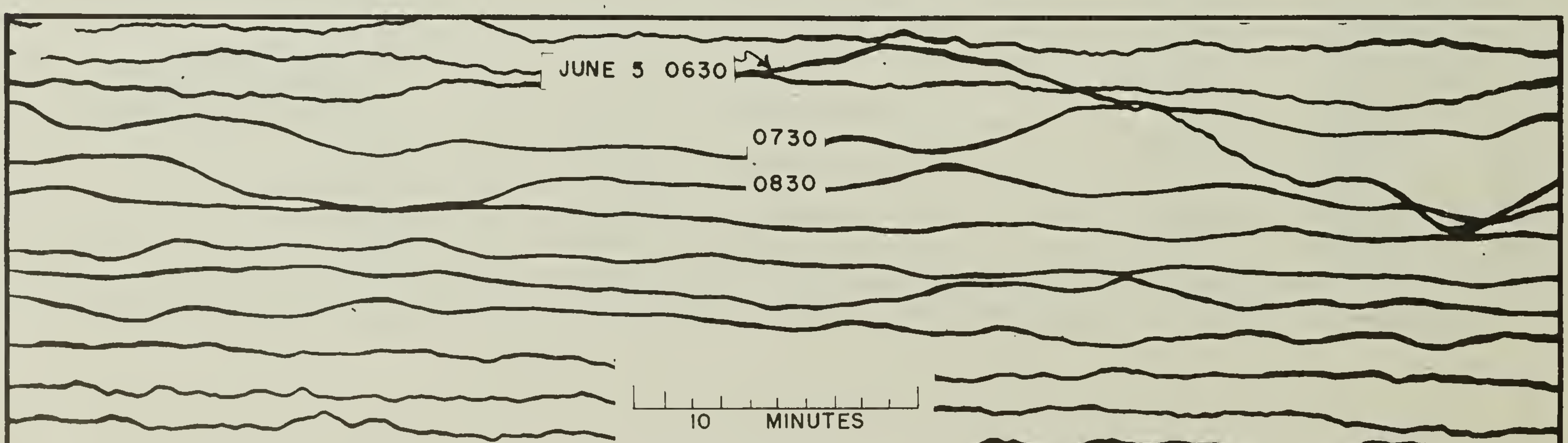

Figure 3. Portion of Oklahoma City microbarovariogram for June 5, 1953. (Times are GMT.)

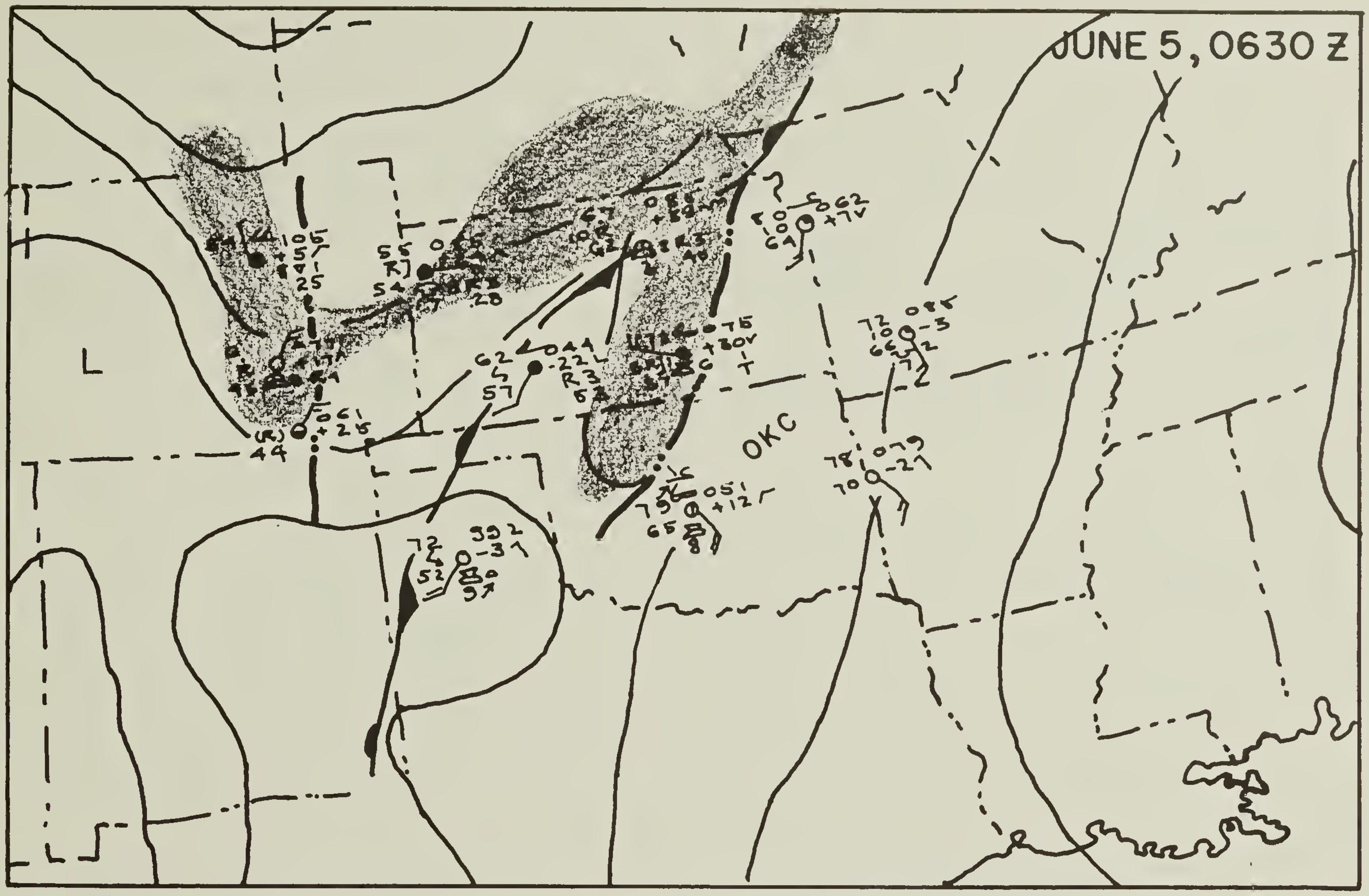

Figure 4. Weather map for Oklahoma City (OKC) and vicinity for June 5, 1953 at 0630 GMT

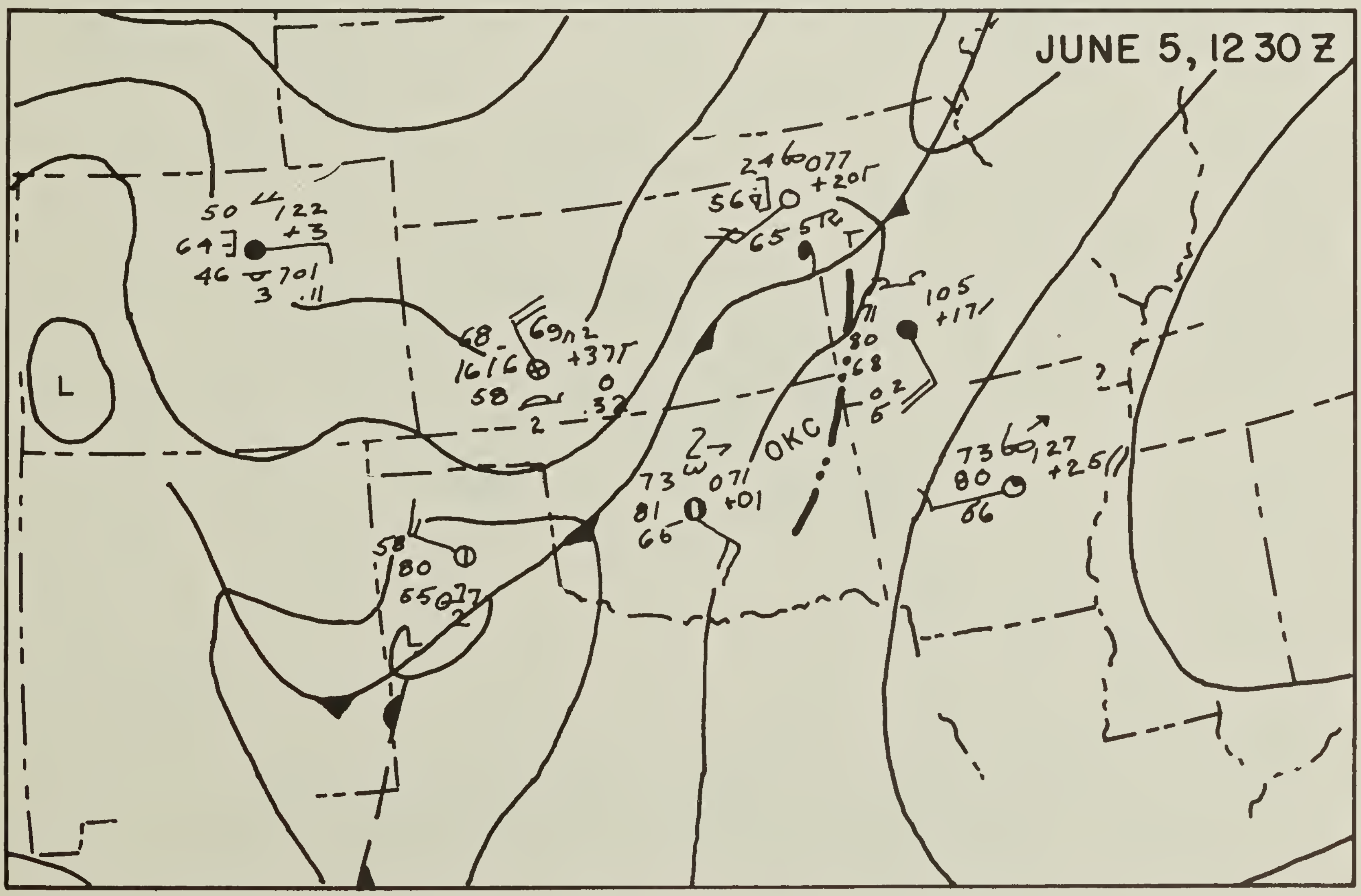

Figure 5. Weather map for Oklahoma City (OKC) and vicinity for June 5, 1953 at 1230 GMT

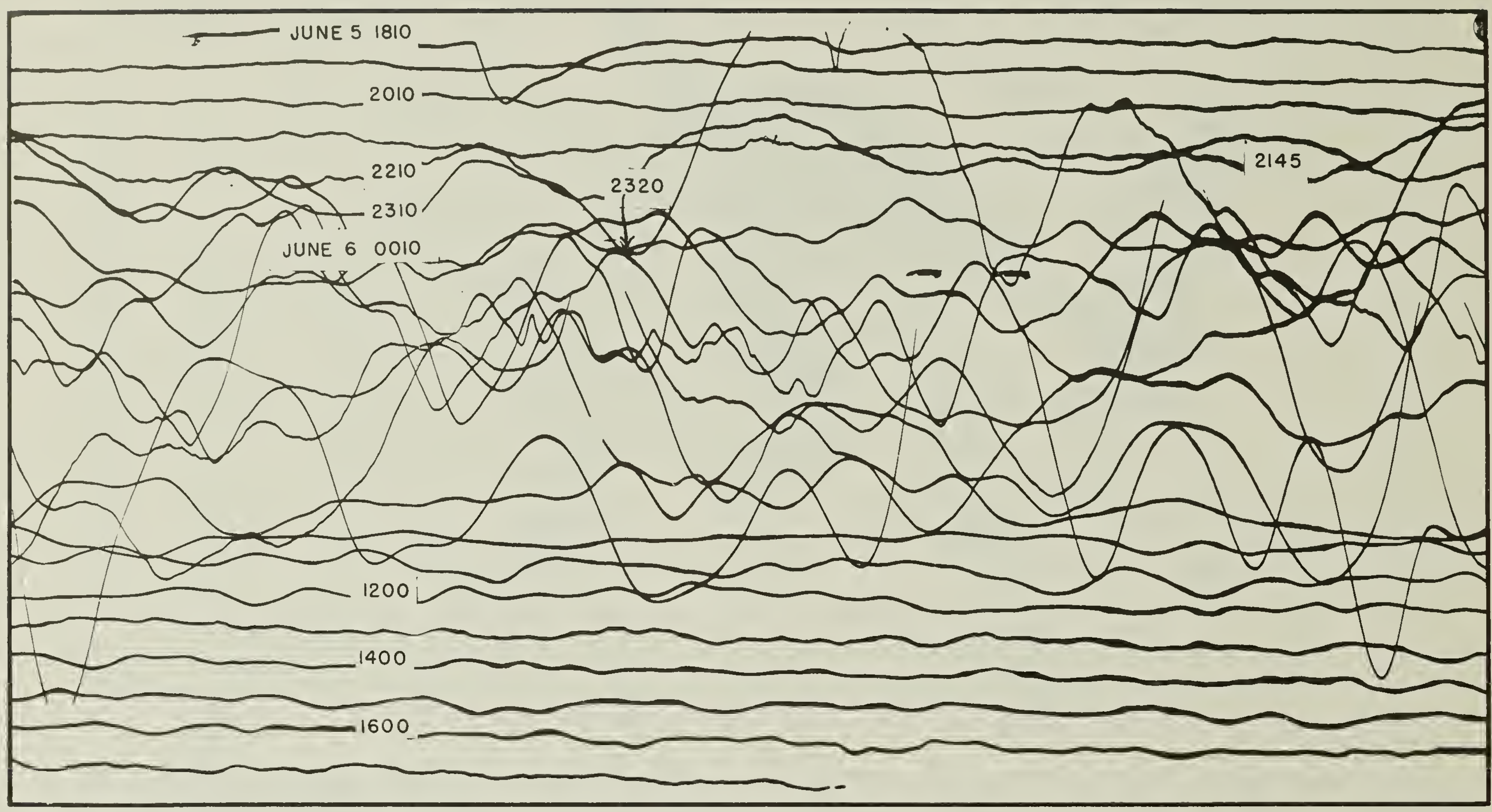

Figure 6. Oklahoma City microbarovariogram for June 5-6, 1953. (Times are GMT.)

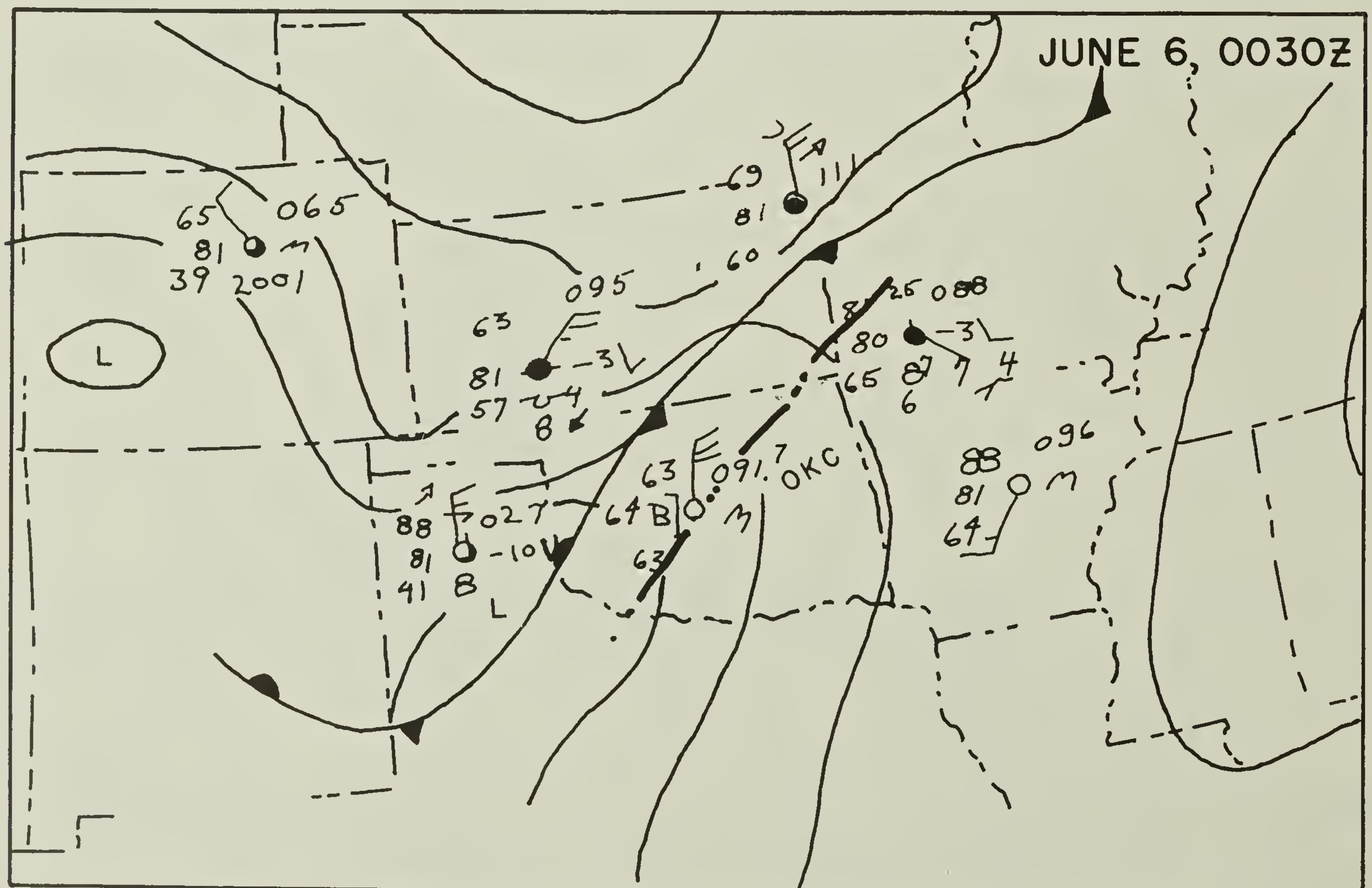

Figure 7. Weather map for Oklahoma City and vicinity for June 6, 1953 at 0030 GMT

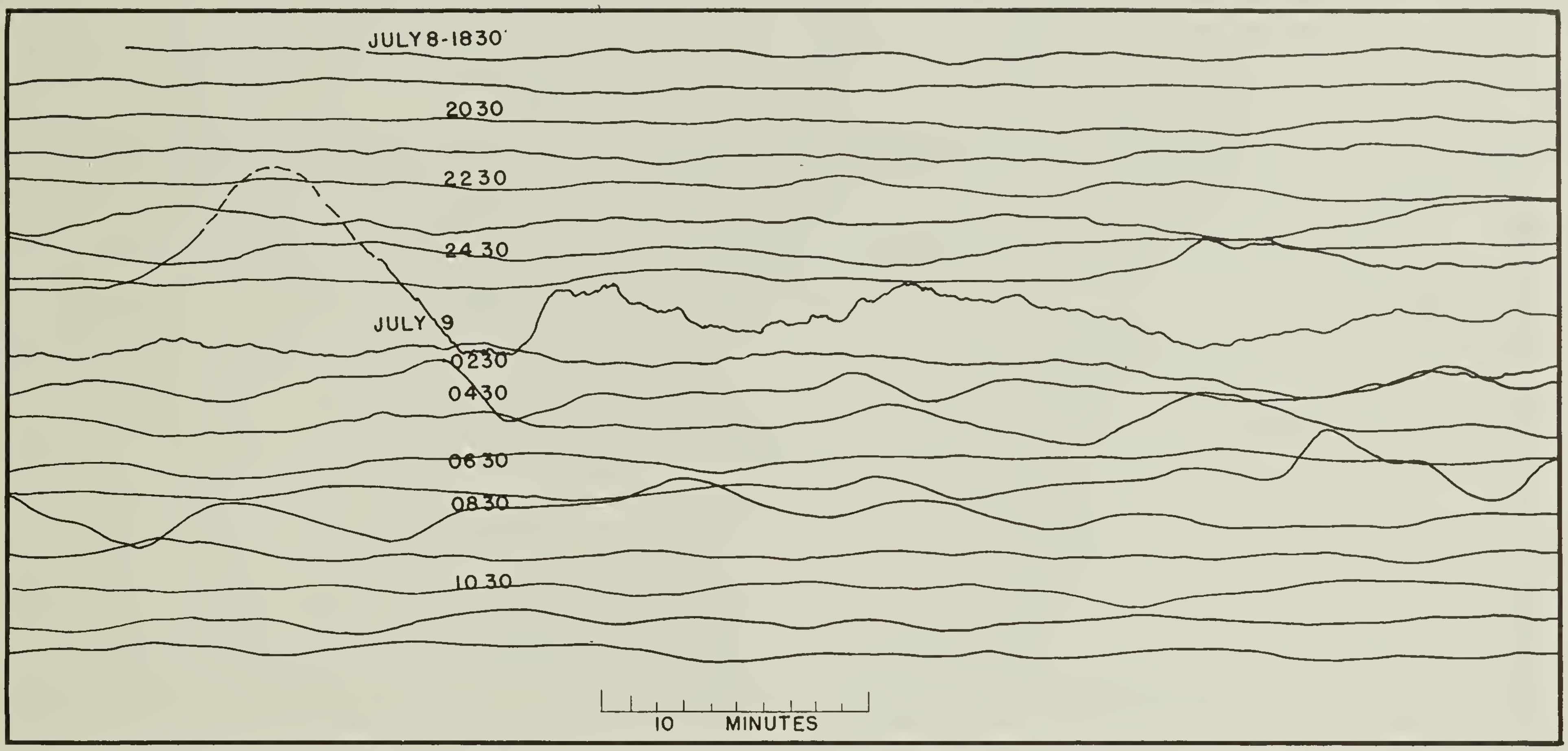

Figure 8. Oklahoma City microbarovariogram for July 8-9, 1953. Times are GMT)

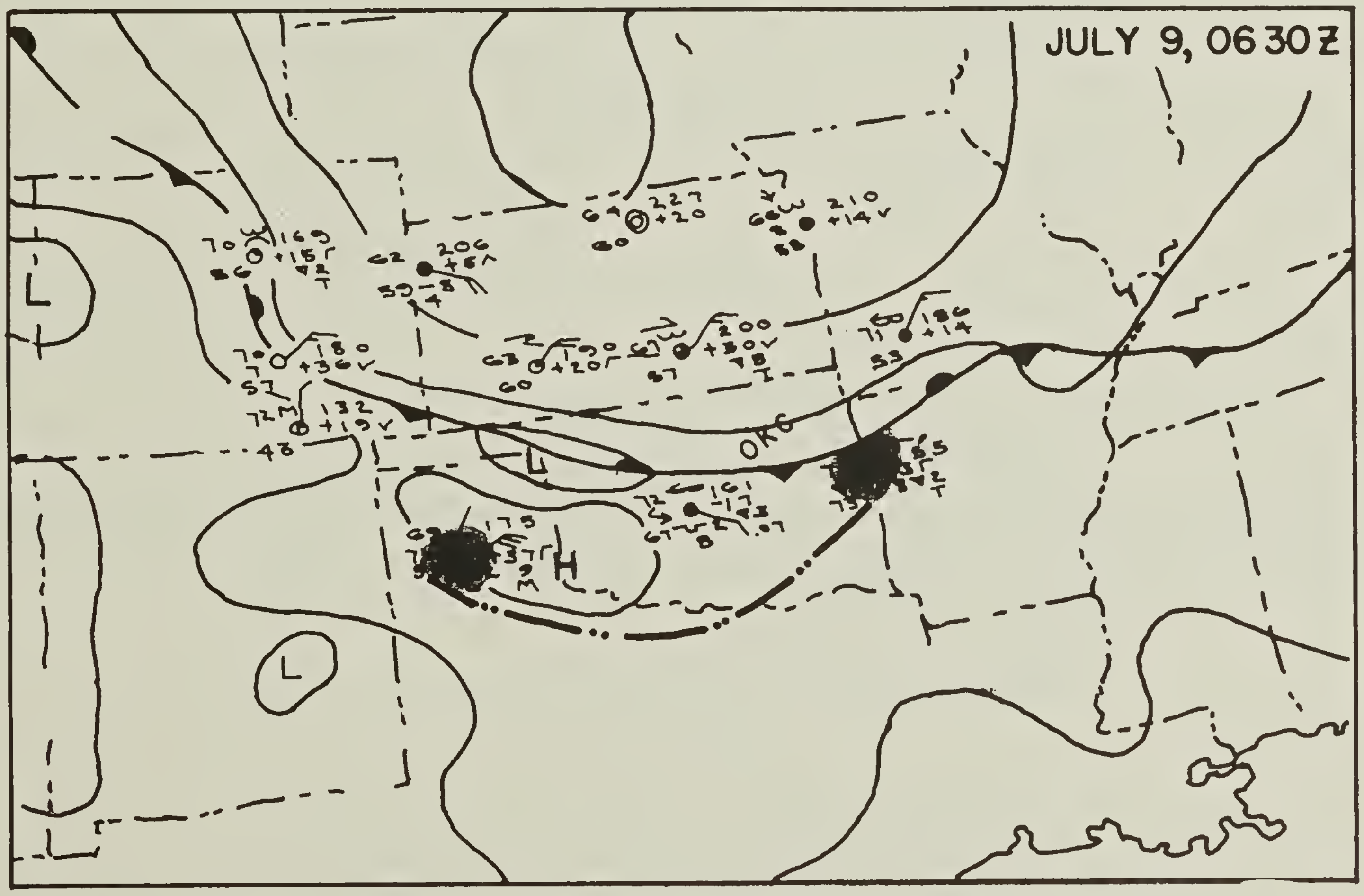

Figure 9. Weather map for Oklahoma City and vicinity for July 9, 1953 at 0630 GMT

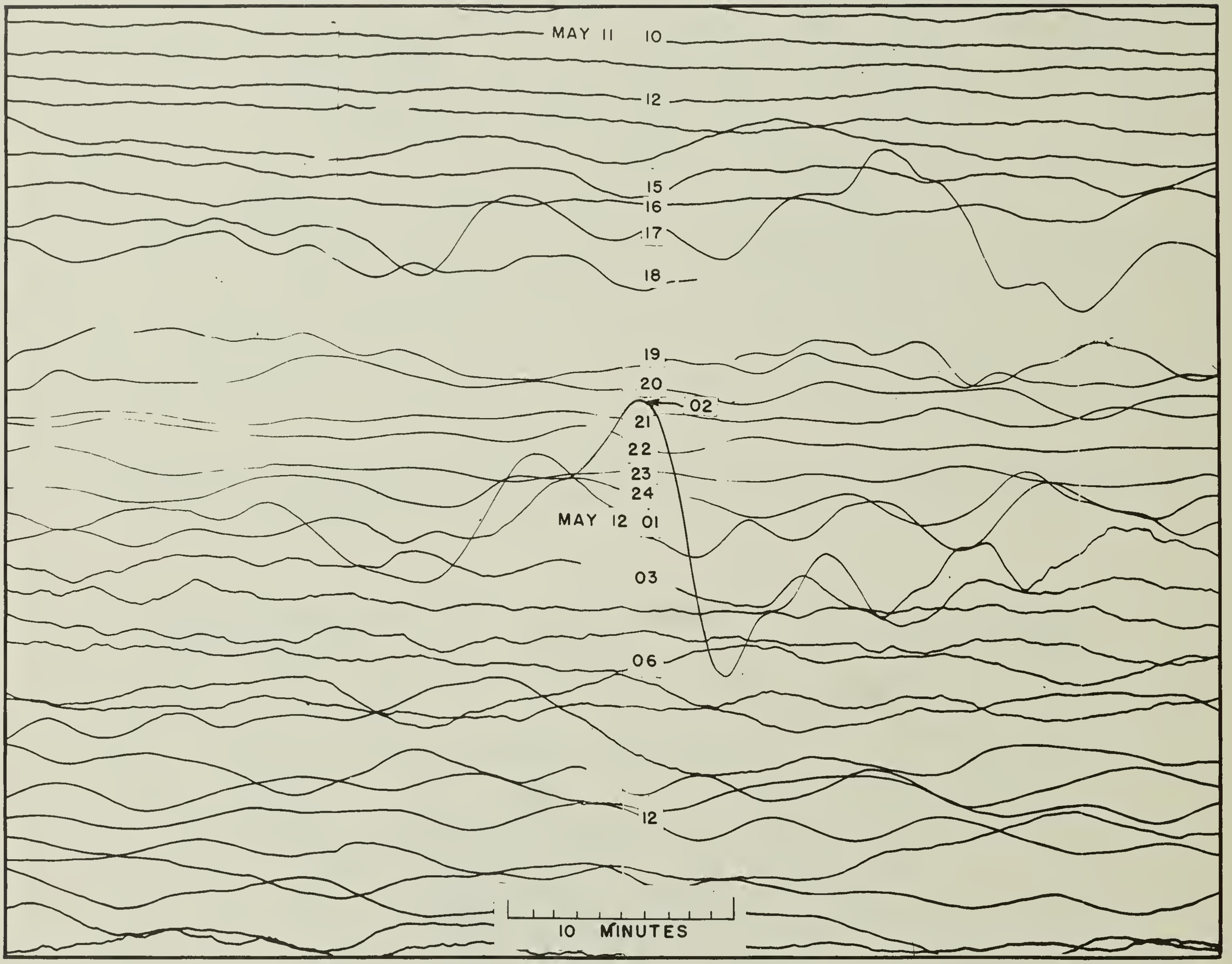

Figure 10. Oklahoma City microbarovariograms for May 11-12, 1953. (Times are GMT.)

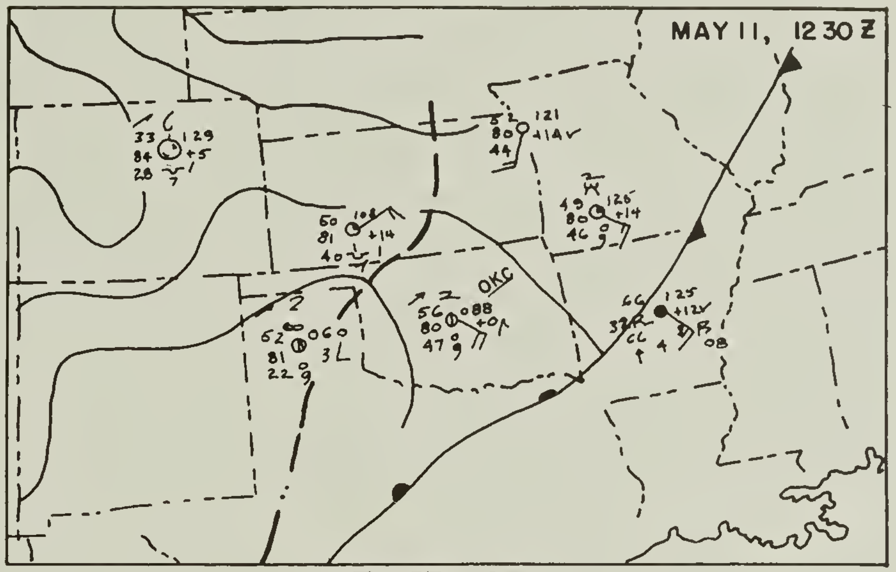

FIGURE 11 A

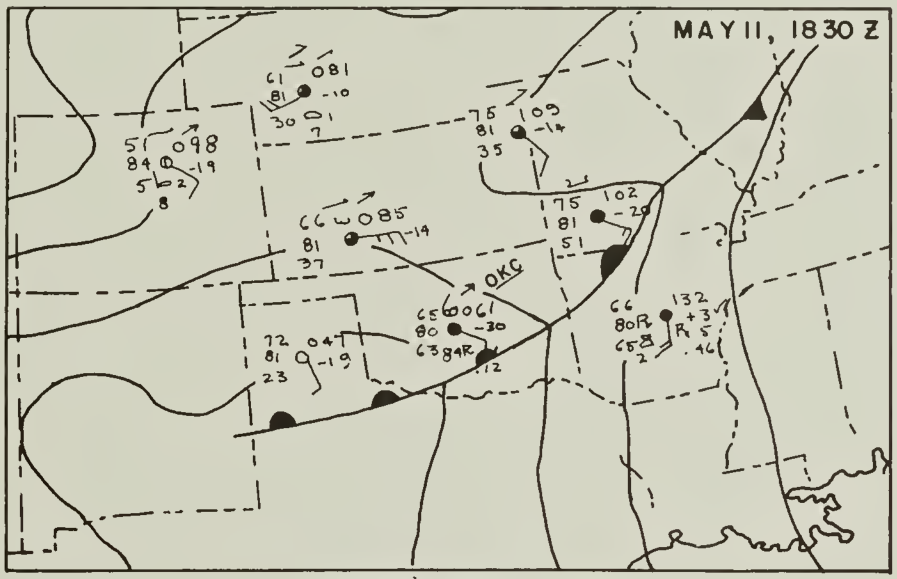

FIGURE 11 B

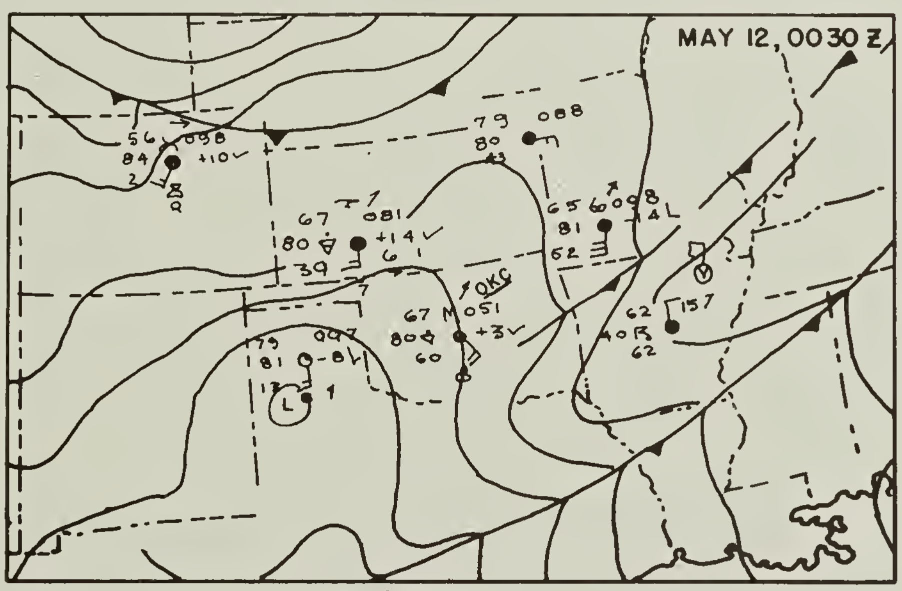

FIGURE 11 C

Figure 11, A, B, C. Maps showing continuity of weather from May 11, 1953 at 1230 GMT to May 12, 1953 at 0030 GMT

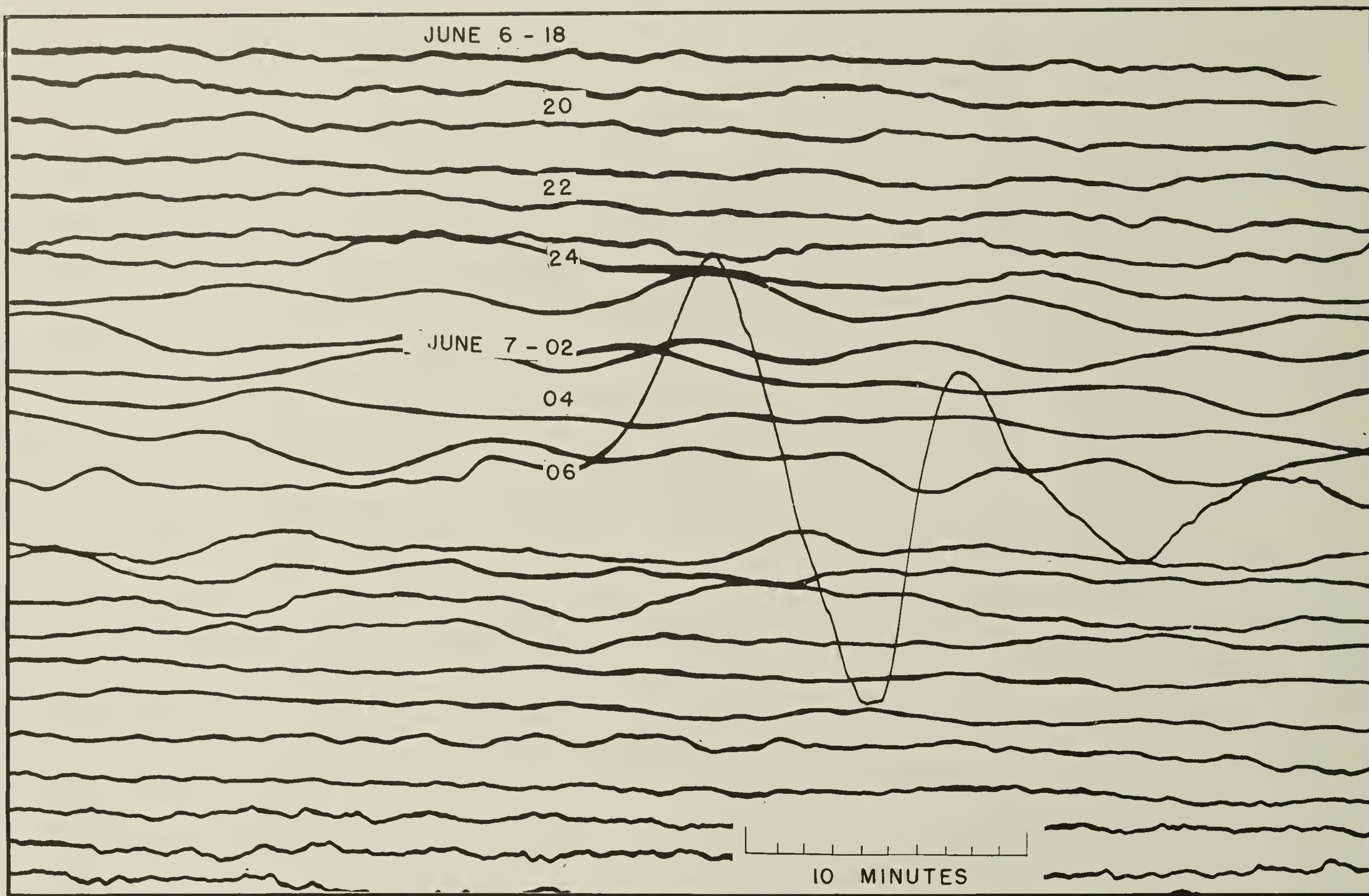

Figure 12. Oklahoma City microbarovariogram for June 6-7, 1953. (Times are GMT.)

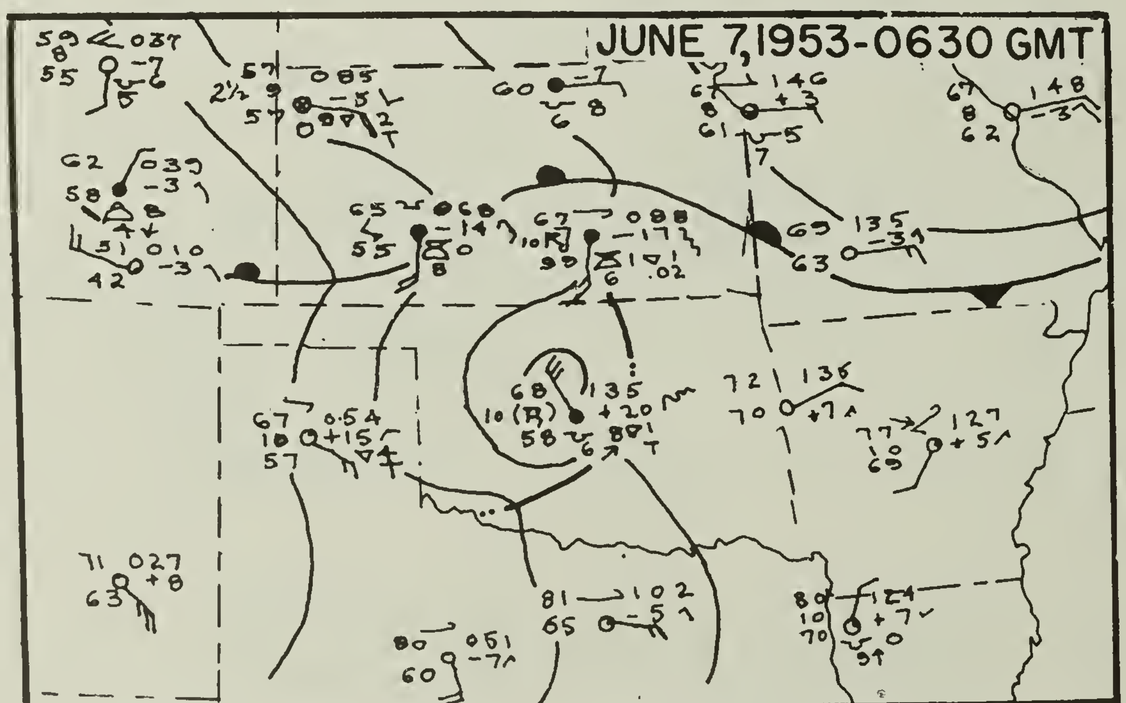

Figure 13